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(54) Locking bone plate

(57) A bone plate (80,130,140,200) of complex form, suitable for use in osteotomy is provided. The bone plate (80,130,140,200) has at least a longitudinal axis (12,204), a bone-contacting bottom side, and a top side (16,206) with apertures that communicate through the plate (80,130,140,200) from the top to the bottom side. The apertures are implemented for taking up bone pegs or bone screws. The apertures are arranged substantially along the axis (12,204). The bone plate according to the invention is characterized in that at least two of these apertures are implemented as sets of two overlapping holes (100,212). Each one of the overlapping holes (100,212) has exclusively cylindrical and multifaceted surfaces (36,214). When the bone plate (80,130,140,200) is applied during surgery, the two sets of overlapping holes (100,212) are located so as to lie on opposite sides of an osteotomy site (112,202). The configuration of this complex bone plate vary, depending on the physiology of the patient. An object of the invention is to provide an orthopaedic surgeon greater flexibility of choice in that a threaded peg providing secure fixing can be positioned at any interval along the bone plate, including at its extreme ends or on its elbow.

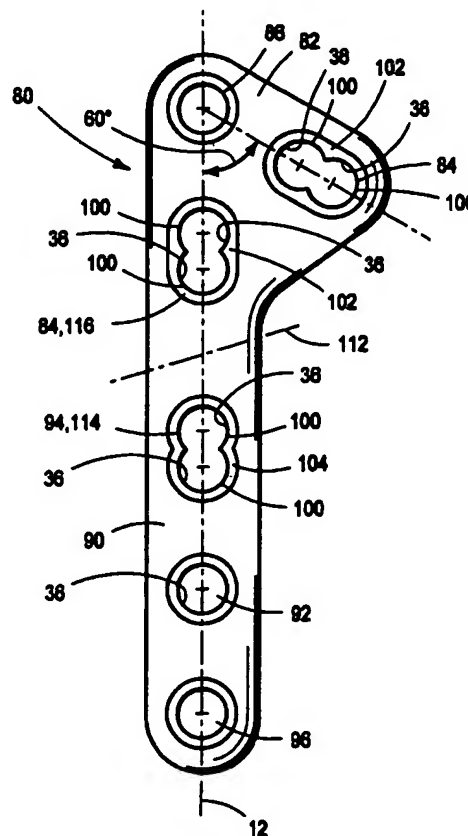


FIG. 1a

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## Description

[0001] This invention relates to devices, implants and prostheses used in orthopaedic surgery, and, more particularly, to bone plates used to reinforce fractured bones and thus promote healing.

[0002] A compressive screw system, also known as the DCS system, is a bone plate system that has been used in trauma surgery for many years. The procedures for use of this system are well documented by the AO Institute, an institute having as one of its goals, the promotion of new orthopaedic surgical procedures. This system included a bone plate having slots communicating therethrough. A land in which the slot is wider at one end defines a stepped surface adjacent the portion of the slot that extends through the bone plate. The stepped surface is generally cut with a spherical endmill, thus creating a spherical stepped surface.

[0003] In a still further development, bone plates have been developed having individual threaded apertures and non-threaded apertures interspersed along the length of the plate. In this and other designs, the distance between holes has become a standard. Although an improvement over the inserts noted above, the locking positions are pre-defined, and only available in limited locations, which also reduce surgical flexibility. In another product variation, expandable, lockable inserts enter into the slots of a standard bone plate. When the bone screw passes through one of these inserts and is torqued down, the insert expands and locks the screw in place. However, this insert is locked in a secondary operation. This is not desirable because this requires more operating room time and adds complexity to the procedure. Further, the inserts must be added in the specific location before the plate is fixed to the bone and cannot be subsequently inserted. This limits the choice of placement during surgery if the need arises.

[0004] Also, the above insert designs rely on a friction lock via contact between two surfaces. Friction locks are not reliable and come loose more easily than threaded locked holes. The result of such a design is inferior to that of the threaded plate and screw designs discussed below.

[0005] In US Patent 5,002,544, there is shown an osteosynthetic pressure plate having a cross-section transverse to the longitudinal axis of the plate at at least one point being wider toward the upper surface than toward the lower surface and the plate having recesses in the lower surface so that upon application to a bone there is space between the bone and the plate. The cross-section between the screw holes is reduced, preferably to the extent that the resistance of the plate to bending in this area is less than in the area of the holes. Because of the reduced bend resistance between the holes, the plate can more easily be adapted to conform to the anatomy of the bone. Furthermore, this can be done without deformation of the holes, thus minimizing the resulting loss of fatigue strength and minimizing the

misfit of the screw heads.

[0006] Further, US Patent No. 5,709,686 describes a bone plate that has recesses or reduced thickness portions on its sides, between threaded apertures. Although the purpose is not specifically described, these recesses appear to function to avoid warpage of the threaded portions when the bone plate is bent. However, when such a bone plate is fixed to a bone, these discontinuous recesses are exposed and may potentially come into contact with and potentially aggravate muscle tissue.

[0007] Still further, US Patent No. 5,733,287 shows, in FIG. 4, a plate that has transverse cuts 13 and a longitudinal cut 14 on the lower surface 7 to reduce contact between the plate and bone. Due to the transverse undercuts 13, the cross-section 15 between the holes is already significantly reduced and therefore is not further decreased by an additional groove 10 on the upper surface 6 as in the embodiment according to FIG. 3. To avoid a cross-section that is too thin, the groove 10 on the upper surface 6 is made discontinuous in short segmental grooves 16 providing a smooth transition into and out of the holes 8.

[0008] In yet another solution, PCT application No. WO 01/54601 combines the features of the DCS system discussed above with a locking screw. This design combines the features of the DCS system with a locking screw. Such a system is known as the combi-slot. In this design, the stepped surface of the slot is generally ramped or tapered so as to be deeper at one end than at another. This enables the positioning and selective fixing of the bone plate for compressing two bone fragments together with a preload created by wedging action. In this manner, the bones are placed in a position that the surgeon believes would best promote healing.

[0009] Further, this combi-hole includes two distinct overlapping portions in a single slot. One portion of the slot is suited to receive a standard bone screw, while the other portion of the slot is suited to receive a threaded peg oriented perpendicular to the top surface of the bone plate. Also, the combi-holes are generally oriented with the threaded portions being on the innermost end of the combination and the unthreaded portions oriented toward the ends of the bone plate. This improvement increased the flexibility of choice available to orthopedic surgeons using the device in that it was more likely that a hole would be present at a suitable anchoring point in the bone plate. Nevertheless, there are often trauma situations that are best served by the threaded portion being at the extreme ends of the bone plate and/or at various positions throughout the plate. In addition, sometimes there is no specific center of the fracture - in such a situation, use of the combi-hole design is limited.

[0010] In a further development, the AO Institute has studied and proposed the use of endpegs which are rigidly fixed in the extreme ends of the bone plate. Such an arrangement has been shown to better resist the flexing of the bone than use of a bone screw alone. Flexing

can otherwise loosen the connection between the bone plate and bone in other bone plate systems.

[0011] US Patent No. 5,324,290 shows a complex bone plate having slots with countersunk circular recessed cut at intervals along the slot (a similar arrangement is shown in US Patent No. 4,696,290). It further shows the bone plate torqued against the bone so as to at least marginally, conform to the shape of the bone (see Fig. 2). Other patents of interest include US Patent Nos. 3,716,050, 3,659,595, 5,681,311, 5,261,910, and 5,364,399, as well as German Patent application DE 43 41 980 A1, all showing combinations of conventional slots and recesses.

[0012] It is therefore an object of the present invention to provide a bone plate that provides greater flexibility of choice to the surgeon. An other object is to suggest a bone plate that provides this choice of plate placement while reliably and permanently fixing the bone plate to the bone fragments, in any hole position. A further object is to propose a bone plate that has multiple orientations for the locking screw and thus, enables plate placement, while reliably and permanently fixing the bone plate to the bone fragments, in any hole position. Still a further object is to provide a versatile bone plate having recesses which determine where the bone plate will bend, in order to avoid the threads in any holes to be bent or warped, while maintaining a smooth external surface. In addition, an object of the present invention is to provide a bone plate with holes that create bidirectional compression.

[0013] These and further objects are achieved by the bone plate as defined in the independent claim 1. Additional inventive elements derive from the depending claims.

[0014] A bone plate(s) of complex form is provided, particularly suited to tibial plateau-leveling osteotomy and a distal femoral osteotomy. The bone plate has a main longitudinal axis, a bone-contacting bottom side (not shown) and a top side with at least two sets of overlapping holes which communicate through the plate from the top to the bottom side. The sets of overlapping holes define threaded apertures having multifaceted surfaces. When applied to a bone, two sets of such overlapping holes are located so as to lie on opposite sides of an osteotomy site. Optionally, a third hole is aligned at approximately 60 degrees with the longitudinal axis. The configuration of this complex bone plate vary, depending on the physiology of the patient. An object of the invention is to provide an orthopaedic surgeon greater flexibility of choice in that a threaded peg providing secure fixing can be positioned at any interval along the bone plate, including at its extreme ends or on its elbow.

[0015] The included drawings represent selected and exemplary embodiments of the present invention. These drawings are intended to illustrate the present invention without limiting the scope of protection. In the Figures is shown:

- Fig. 1a a top view an alternate embodiment suitable for tibial plateau-leveling osteotomy.
- Fig. 1b a view showing placement of the embodiment of FIG. 1a applied in tibial plateau-leveling osteotomy.
- Figs. 2 and 3 top views of other alternate embodiments suitable for tibial plateau-leveling osteotomy.
- Fig. 4a a top perspective view of another alternate embodiment of the bone plate.
- FIG. 4b a bottom perspective view of the alternate embodiment of FIG. 4a.
- FIG. 5a a top view of an alternate embodiment suitable for distal femoral osteotomies.
- FIG. 5b a view showing placement of the embodiment of FIG. 5a applied in a distal femoral osteotomy.
- FIG. 5c an alternate perspective top view of the embodiment of FIG. 5a.
- FIG. 5d an alternate top view showing the positioning of compression holes with respect to the osteotomies.
- FIG. 6 a top view of an orthopaedic kit of the invention.

[0016] Referring now to FIG. 1a, a bone plate 80 of complex form is shown, particularly suited to tibial plateau-leveling osteotomy. The bone plate 80 has a main longitudinal axis 12, a bone-contacting bottom side (not shown) and a top side 16 with at least two sets of overlapping holes 100 which communicate through the plate from the top to the bottom side. The sets of overlapping holes 100 define threaded apertures having multifaceted surfaces 36. When applied to a bone, two sets of such overlapping holes 100 are located so as to lie on opposite sides of an osteotomy site 110. A third hole is aligned at approximately 60 degrees with the longitudinal axis 12, on the elbow portion.

[0017] The configuration of this complex bone plate 80 may vary, depending on the physiology of the patient. An illustration of the flexibility of application of the plate 80 is its flexible use in osteotomy.

[0018] The plate 80 has a flat triangular head 82 in which three spaced-apart apertures 84 and 86 are formed. The head 82 is integrally formed with an elongated lower portion 90 in which are located a plurality of apertures 92, 94 and 96, substantially co-axially with two of the apertures 84 and 86 in the head 82. Apertures 84

and 94 each consist of two overlapping holes 100 and a top lead-in feature which is either an elongated chamfer 102 or two overlapping chamfers 104.

[0019] Referring again to the triangular head 82, the apertures are arranged such that the aperture or hole 84 which is not axially aligned with the other apertures, is angled approximately 60 degrees from the longitudinal axis 12, which corresponds to a nominal angle of correction of the level of the tibial plateau. The osteotomy 110 (shown in FIG. 1b) is located approximately along the line 112, between the aperture designated 114 and the aperture designated 116. These apertures 114 and 116 are formed to enable compression of the fracture site across the line 112 when bone screws 24 having a bevelled surfaces 120 and 122 preferably having no thread 30 on the head 26) enter the apertures and are torqued down such that wedging action takes place at the interface between the bevelled surfaces and the chamfered surfaces 102 and 104.

[0020] The aperture 116 has a chamfer 102 that allows a surgeon to insert a bone screw 24 (shown in FIG. 6) in the region between the holes 100 and not tighten completely, thus allowing movement along the long axis 12 and accurate placement of the bone plate 80 upon tightening. Note that aperture 114 may be used in a similar manner to aperture 116, the difference being that the form 104 of the chamfer does not allow for the placement of the screw 24 at any position along the length of the aperture (rather, there are only two possible positions: coaxial with the holes 100). The holes 92 and 96 may include threads 30 that are locking or non-locking, depending on the particular need of the surgeon.

[0021] Referring now to FIG. 1b, application of the bone plate 80 is shown for tibial plateau-leveling osteotomy in a canine subject. It should be noted, however, that there are several suitable veterinary and human orthopaedic applications as well.

[0022] Referring now to FIG. 2, an alternate embodiment 130 of the invention for this particular application shows typical modifications, such as longer chamfer surfaces 102' and 104' in the apertures 84' and 94' on either side of the osteotomy site. An elongated slot 86' in the flat, triangular head 82' includes a large underside chamfer (not shown) which permits greater bone screw angulation.

[0023] Referring now to FIG. 3, a second alternate embodiment 140 of the invention for this particular application shows other possible orientations of the apertures. For example, apertures 84" are oriented off axis in order to suit special cases.

[0024] Note that the threaded apertures 100 used in the invention provide hole centers located at specific locations (as opposed to apertures that are formed as a slot). Use of threads centered at a specific point allows the bone screw to be fixed at a specific location at which the surgeon may judge the bone structure to be best suited to support such a bone screw. Unlike designs using a slot, the apertures 100 of the invention eliminate

wander of the screw in the aperture. This further permits placement at specific locations for buttressing and/or secure fixing in neutral screw loading areas.

[0025] Referring now to FIGs. 4a and 4b, in another embodiment, the bone plate 80' has a round hole 150 having a countersink 152 whose axis 154 is angled off of perpendicular from the top surface 156 of the bone plate and whose form corresponds to the shape of the head of a representative bone screw. The angle from perpendicular is preferably 25 degrees as this angulation generally matches the amount which the plate 80' is contoured *in situ*. This angle allows screw placement that is parallel to the adjacent bone surface.

[0026] Referring now to FIGs. 5a-5d, in another embodiment, a bone plate 200 is particularly suited for distal femoral osteotomies 202 and correcting medial patellar luxations and/or other corrective osteotomies of the distal femur. The bone plate 200 has a main longitudinal axis 204, a bone contacting bottom side (not shown) and a top side 206 with at least two adjacent sets 210 of overlapping holes 212 which communicate through the plate from the top to the bottom side. The sets 210 of overlapping holes are compression holes which define threaded apertures 212 having multifaceted surfaces 214. When applied to a bone 216, two sets 210 of such overlapping holes 212 are located so as to lie on opposite sides 216 of an osteotomy site 202.

[0027] The threaded apertures 212 include wide bevels 220 on a far end 222 and near end 224 with respect to the osteotomy site.

[0028] The bone plate 200 further includes at least one locking bone peg (not shown) having an unthreaded body and threaded head which locks with the threads of a corresponding threaded aperture, thereby better ensuring rigid fixing of a fracture. Further, the distance X between the threaded apertures is defined to optimize either closing or opening of wedge femoral osteotomies 230. Preferably, the distance X is approximately 15 mm.

[0029] Optionally, a distal end 232 of the plate 200 forms a natural curve 234 corresponding to the shape 236 of the distal femur in order to minimize the potential of plate overhang.

[0030] In another feature, locking bone pegs 306 (shown in FIG. 6) interface with the threaded apertures. The threads cut in the head of these pegs are designed so as to lock with the threaded apertures in order to better ensure rigid fixing of a fracture when using pegs having a body without threads. The locking feature used can be any of the known methods of locking threads by mechanical means.

[0031] Referring now to FIG. 6, in another embodiment, an orthopaedic kit 300 is provided which include a case 302, bone plates 200 and 200', a variety of bone screws 304, threaded pegs 306 of various lengths, and a drill guide 310. The drill guide 310 has a threaded end 312 that threads into the thread 40 of an overlapping hole 210. The drill guide 310 has a main drill guide surface 314 to securely hold the drill guide in a desired ori-

entation with respect to the bone plate 200 in order to stabilize a drill (not shown) used in an orthopaedic procedure.

[0032] In an advantage of the invention, the bone plate 10 provides greater flexibility of choice to the surgeon in that a threaded peg providing secure fixing can be positioned at any interval along the bone plate, including at its extreme ends. In another advantage, the bone plate 10 provides greater flexibility of choice by providing multiple overlapping holes 22 oriented (1) along the longitudinal axis 12 of the bone plate, (2) oriented at an angle  $\theta$  to the longitudinal axis, and (3) staggered along the axis.

[0033] In still another advantage, the threaded apertures 40 of the bone plate 10 are provided with threads cut perpendicular to the top side 16 of the bone plate, as well as at an angle  $\theta$  to normal.

[0034] In another advantage, the bone plates 80, 130, or 140 include features that further increase the adaptability of the invention to the particular needs of surgery, in this instance, tibial plateau-leveling osteotomy.

[0035] Multiple variations, combinations, and modifications are possible in the embodiments of the invention described here. Although certain illustrative embodiments of the invention have been shown and described here, a wide range of modifications, changes, and substitutions is contemplated in the foregoing disclosure. In some instances, some features of the present invention may be employed without a corresponding use of the other features. Accordingly, it is appropriate that the foregoing description be construed broadly and understood as being given by way of illustration and example only, the spirit and scope of the invention being limited only by the appended claims.

## Claims

1. A bone plate (80,130,140,200) of complex form, suitable for use in osteotomy, the bone plate (80,130,140,200) having at least a longitudinal axis (12,204), a bone-contacting bottom side and a top side (16,206) with apertures that communicate through the plate (80,130,140,200) from the top to the bottom side, the apertures being implemented for taking up bone pegs or bone screws, and the apertures being arranged substantially along the axis (12,204), characterized in that at least two of these apertures are implemented as sets of two overlapping holes (100,212), wherein each one of the overlapping holes (100,212) has exclusively cylindrical and multifaceted surfaces (36,214), and wherein, when the bone plate (80,130,140,200) is applied during surgery, the two sets of overlapping holes (100,212) are located so as to lie on opposite sides of an osteotomy site (112,202).
2. The bone plate (80,130,140,200) of claim 1, char-

acterized in that the centers of the overlapping holes (100,212) are arranged substantially parallel to the longitudinal axis (12,204).

3. The bone plate (80,130,140,200) of one of claims 1 or 2, characterized in that a third hole (102) is aligned in a distance to the longitudinal axis (12,204).
4. The bone plate (80,130,140,200) of one of claims 1 to 3, characterized in that the bone plate (80,130,140,200) has a second axis on which bone screw receiving holes are located, the second axis being angled from the longitudinal axis (12,204).
5. The bone plate (80,130,140,200) of claims 3 and 4, characterized in that the third hole (102) is implemented as a set of overlapping holes (100,212) arranged substantially parallel to the second axis.
6. The bone plate (80,130,140,200) of claims 4 or 5, characterized in that the second axis is angled at 60 degrees from the longitudinal axis.
7. The bone plate (80,130,140,200) of one of claims 1 to 6, characterized in that the multifaceted surfaces (36,214) of the overlapping holes (100,212) are threads (40).
8. The bone plate (80,130,140,200) of one of claims 1 to 7, characterized in that each one of the overlapping holes (100,212) includes a wide bevel (220) on a far end (222) away from the osteotomy site (112).
9. The bone plate (80,130,140,200) of one of claims 1 to 8, characterized in that the bone plate (80,130,140,200) further includes at least one locking bone peg (306) having a threaded head which locks with the threads (30) of a corresponding threaded aperture (40), thereby better ensuring rigid fixing of a fracture when using pegs having a body without threads.
10. The bone plate (80,130,140,200) of one of claims 1 to 9, characterized in that the bone plate includes at least one round hole (150) having a corresponding countersink (152), the countersink being axially offset from an orientation perpendicular to the top surface (156) by a predetermined angle.
11. The bone plate 80,130,140,200) of claim 10, characterized in that the predetermined angle is 25 degrees.
12. The bone plate (80,130,140,200) of one of claims 1 to 11, characterized in that a distance (X) between the two overlapping holes (100,212) of an aperture

is defined to optimize either closing or opening of wedge femoral osteotomies.

13. The bone plate (80,130,140,200) of claim 12, characterized in that the distance (X) is 15 mm. 5
14. The bone plate (80,130,140,200) of claim 12 or 13, characterized in that a distal end (232) of the plate (80,130,140,200) forms a natural curve corresponding to the shape of the distal femur in order to minimize the potential of plate overhang. 10
15. An orthopedic kit including a bone plate (80,130,140,200) of complex form, suitable for use in osteotomy according to at least one of the claims 1 to 14 and at least one bone screw engageable with the bone plate (80,130,140,200). 15
16. The orthopedic kit of claim 15, further comprising a drill guide having a main drill guide surface and opposite end portions, one end portion of which is securely engageable with the multi-faceted surface of a hole in the bone plate (80,130,140,200) so as to securely hold the drill guide in a desired orientation with respect to the bone plate (80,130,140,200) for stabilizing a drill used in an orthopedic procedure. 20 25

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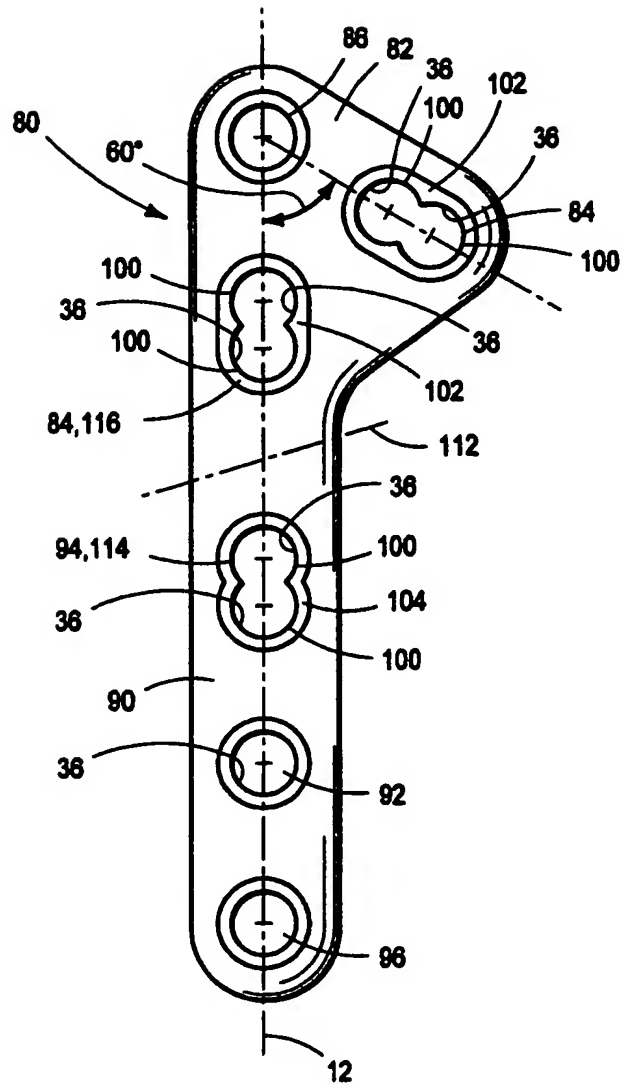


FIG. 1a

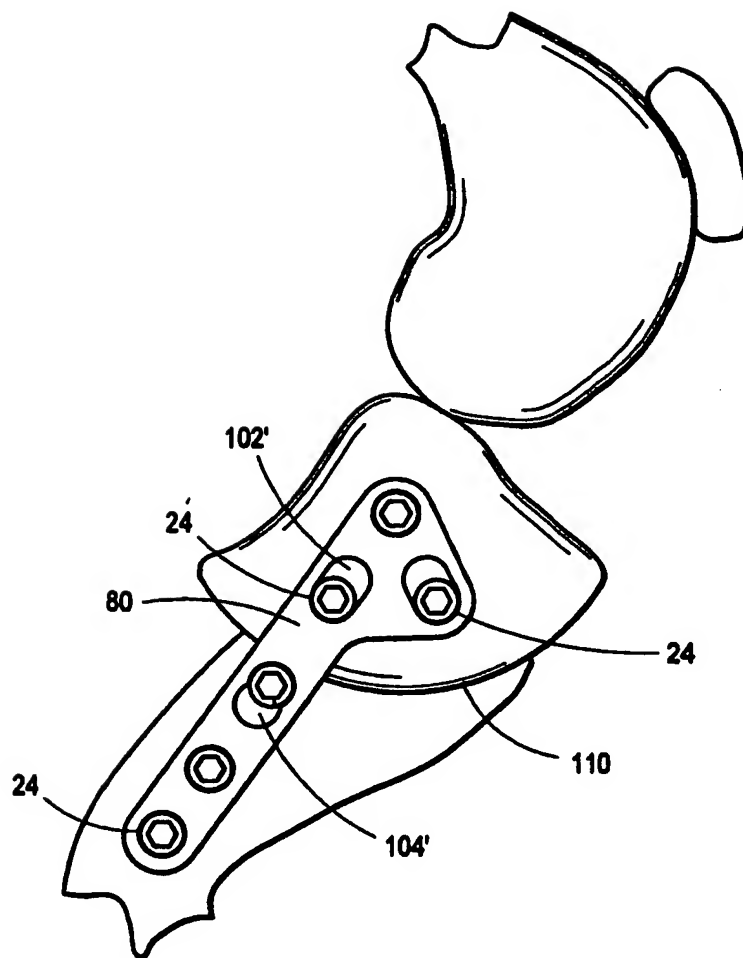


FIG. 1b



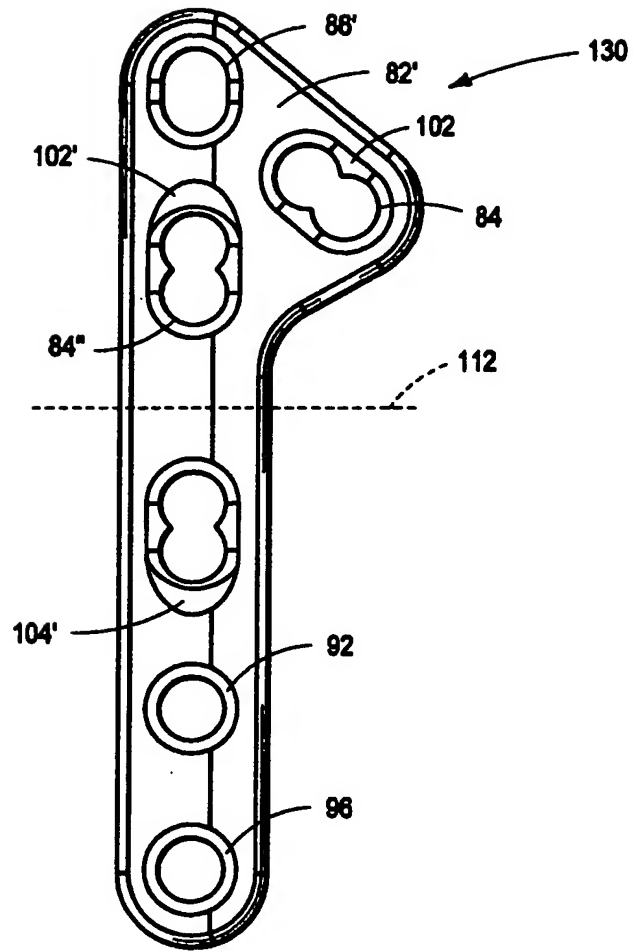


FIG. 2

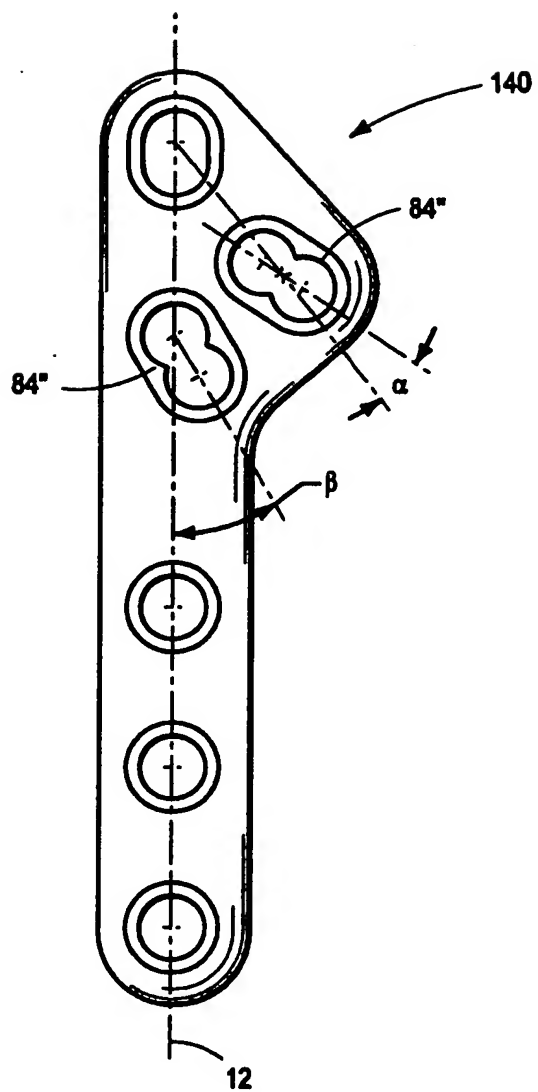


FIG. 3

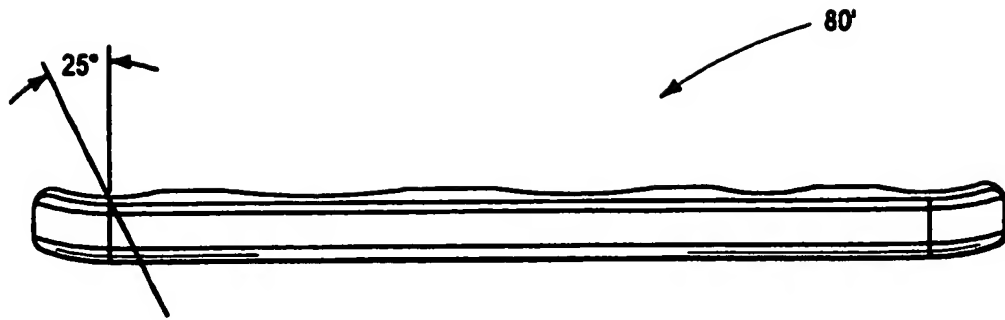


FIG. 4a

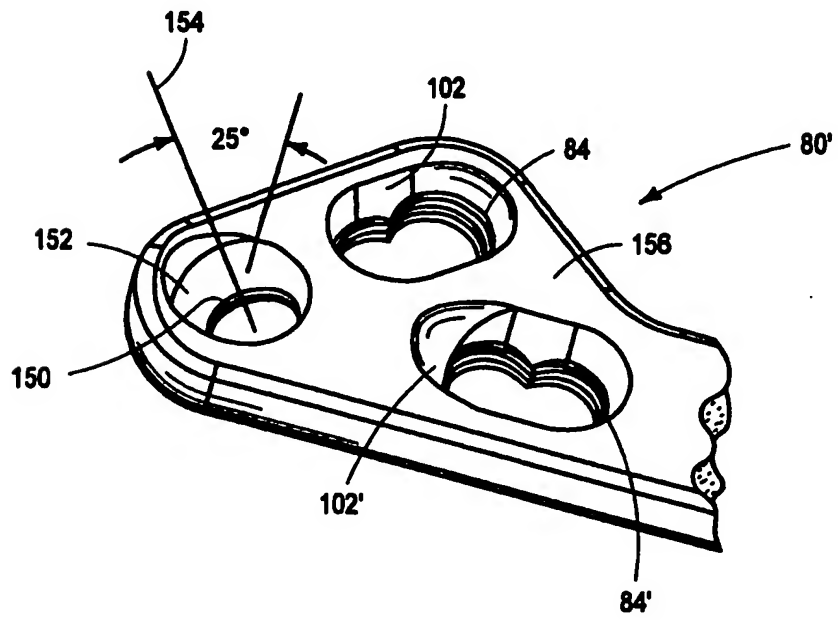


FIG. 4b

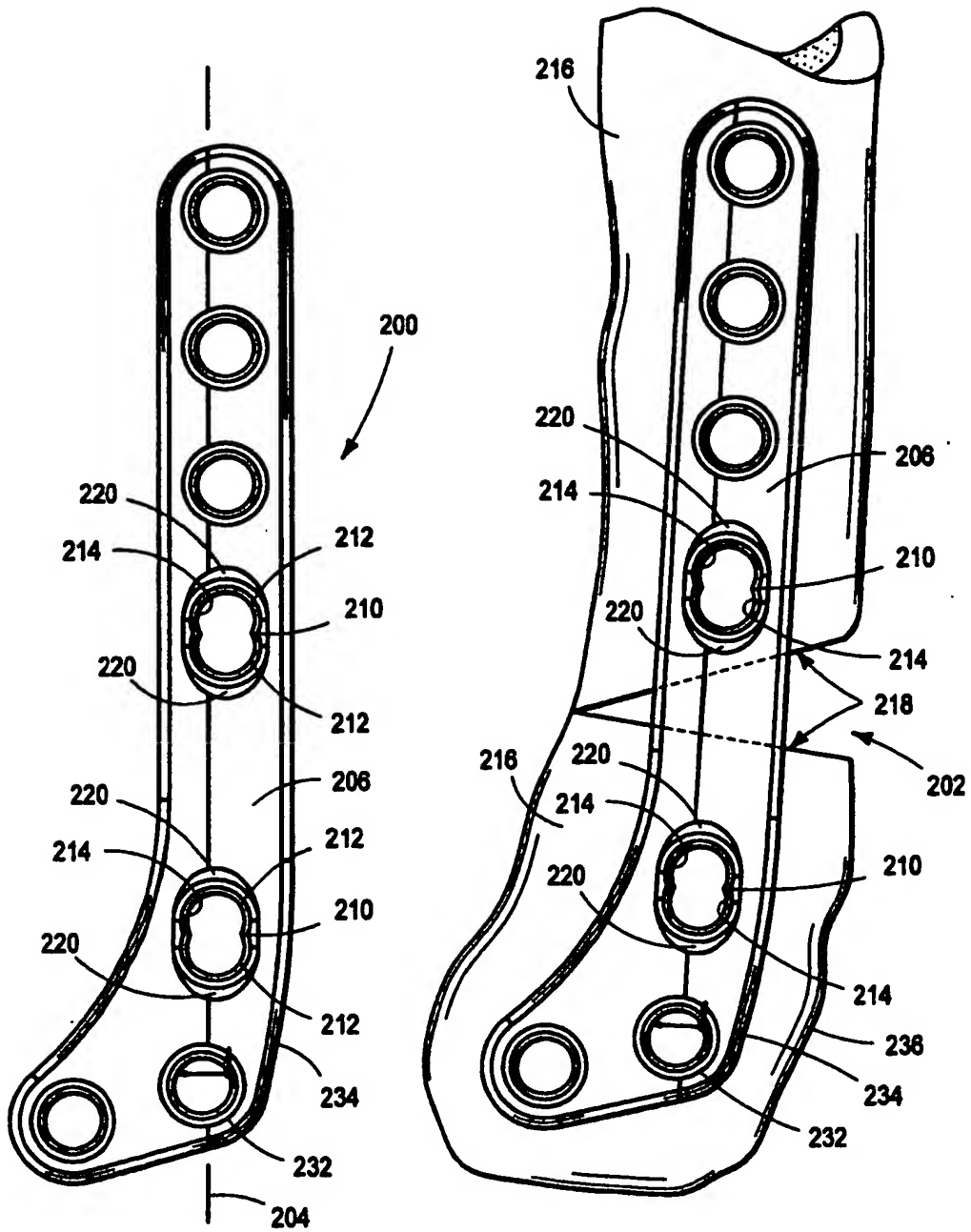
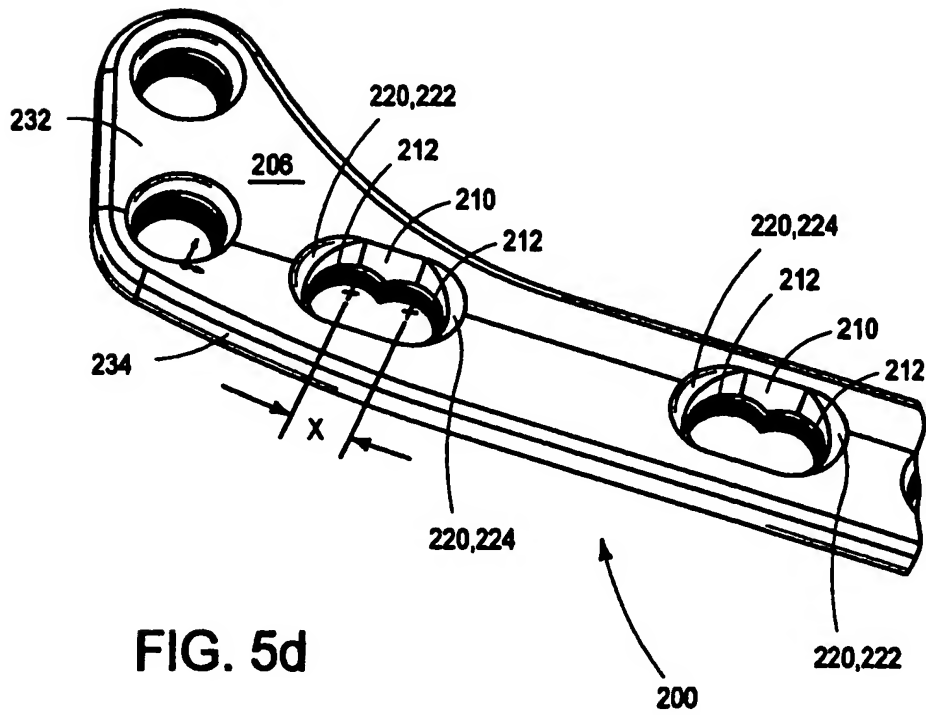
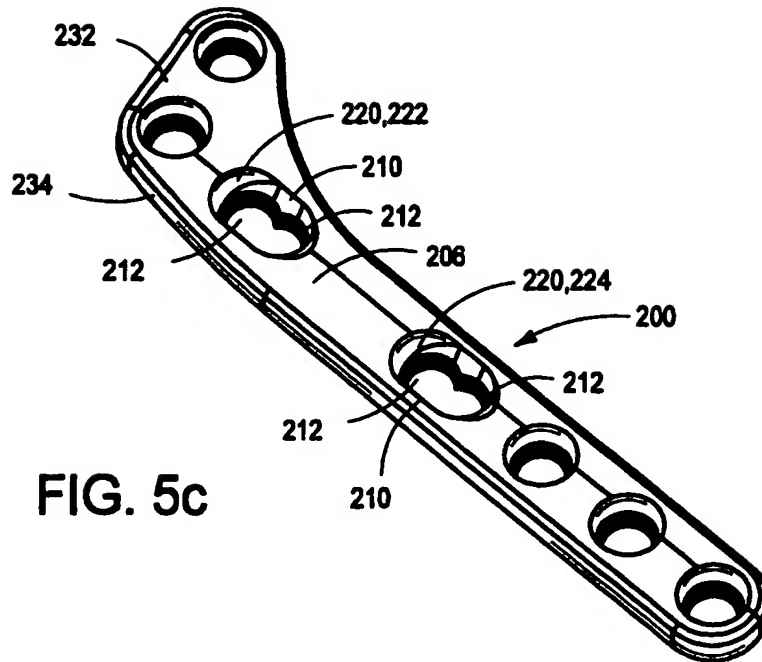


FIG. 5a

FIG. 5b



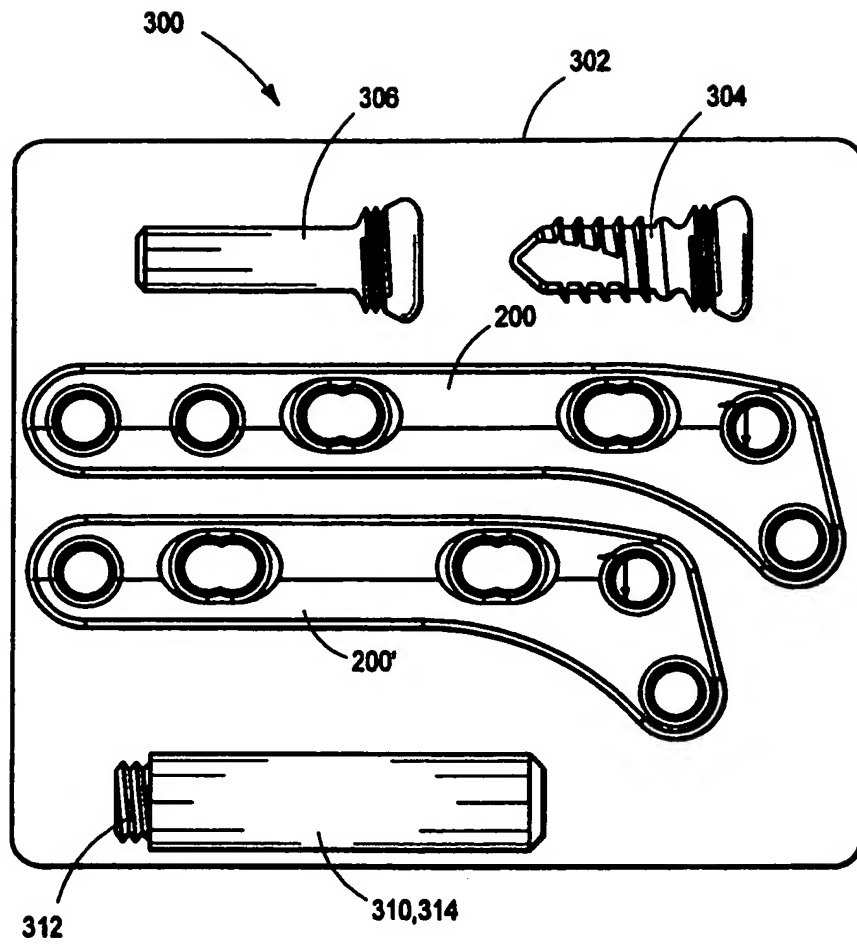


FIG. 6